ASSESSING SMALL STREAM BIOTIC INTEGRITY USING FISH ASSEMBLAGES ACROSS AN URBAN LANDSCAPE

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Extended Abstract (excerpted from Matzen and Berge, *in prep*)

Freshwater ecosystems in the Pacific Northwest (PNW), like those around the world, have been degraded due in large part to effects of human activity across the landscape (Meehan 1991; Doppelt et al. 1993; Naiman et al. 1995; Schindler 2001; Van Sickle et al. 2004). In the Puget Sound region, attention has focused on the need to evaluate and monitor the condition of freshwater ecosystems as salmonid species are added to the endangered species list. Ecological indicators have been recognized as a valuable tool because they allow direct observation of complex organisms that are subject to current conditions, as well as cumulative effects (Karr 1981; Karr and Chu 1999). The index of biotic integrity (IBI) is one such ecological indicator, composed of multiple metrics that assess the response of biotic assemblages to many complex stressors (Karr et al. 1986).

In the Pacific Northwest (PNW) freshwater systems are characterized by cold water streams with low biological diversity of fish and amphibians, making development of an IBI based on species richness difficult (Sparling et al. 2001). Unlike warm water Midwestern streams, little variation is observed in habitat preferences, trophic guilds, and reproductive strategies of fish in the PNW (Hughes et al. 2004). For this reason, the benthic macroinvertebrate IBI (BIBI) has been used extensively to characterize stream health across the Puget Sound lowland ecoregion instead of fish assemblages. The link between benthic macroinvertebrates and fish is clear, as the health of fish populations are dependent on appropriate food sources, yet direct measurement of this visible and culturally important component of the watershed has not been pursued. Therefore, the purpose of this study was to determine if a FIBI for small streams could be developed and used as part of an ecological risk assessment in the Greater Lake Washington Watershed and to test its suitability to detect changes in fish assemblages in response to urbanization.

The dataset used to develop our FIBI was collected in 1996 and included 70 sampling events in 30 subbasins (Ludwa et al. 1997). Additional data were gathered from other sources to create a validation dataset of 79 sampling events in 18 subbasins over an eleven-year period (1993-2003). Urbanization was characterized using 2001 Landsat ™ imagery. Three measures of urbanization were used: total impervious area (TIA), percent urban land use, and percent vegetative land use. Road density was calculated in GIS using the King County Street Network data layer based on TIGER data and protocols adopted from Alberti et al. (2003).

A literature search was conducted to identify potential metrics to be included in the FIBI. Emphasis was placed on studies that were either conducted in the PNW or suggested metrics for this region. Additionally, new metrics were formed and tested during metric evaluation. Fifty potential metrics were identified and evaluated. Each metric that was based on a species-specific attribute was evaluated using attribute designations from Zaroban et al. (1999). Of the 50 potential metrics evaluated using linear regression and the development dataset, 13 were considered for inclusion in the final index. Metrics for each sampling event were scored according to the scheme established using the development dataset, with integer scores assigned from 0 to 5. In order to identify the most appropriate set of metrics, scores from the thirteen candidate metrics were combined in different combinations and sums were compared to TIA using linear regression. The combination of metrics that resulted in the strongest correlation with TIA was used as the final set of FIBI metrics. The final FIBI was comprised of seven metrics, including percent tolerant individuals, percent invertivore individuals, percent omnivore individuals, percent benthic individuals, percent coho salmon individuals, percent cutthroat trout individuals, and the percent individuals of the two most abundant species.

The final index score was calculated from the sum of the metric scores. The maximum possible FIBI score was 35. Scores from the development dataset ranged from 8 to 30. FIBI scores from the validation datasets ranged from 10 to 30. The FIBI was strongly correlated to all four measures of urbanization, total impervious area (TIA; $R^2 = 0.6$, $p < 0.001$), urban land use ($R^2 = 0.57$, $p < 0.001$), vegetative land use ($R^2 = 0.56$, $p < 0.001$), and road density ($R^2 = 0.6$, $p < 0.001$). Comparison of the range of FIBI scores in subsequent basins between 1993 and 2003 showed

declining conditions over time and indicated that the index was sensitive to changes in biotic integrity resulting from degradation due to increasing urbanization.

Despite the low diversity of biota and the influence of natural variation in fish assemblages due to spatial and temporal anomalies, the FIBI showed a strong negative response to urbanization. The sensitivity of the FIBI to urbanization demonstrates the usefulness of the index as a management tool. It is not, however, our suggestion that the FIBI be used as the only management tool. Ecosystems are complex and thus require the use of multiple indicators in establishing important management decisions. Other factors should be considered in freshwater ecosystem management such as benthic macroinvertebrates, in-stream habitat, riparian condition, water quality, hydromodifications and flow alteration.

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